GRI-98/0367.1

DEVELOPMENT OF THE B31.8 CODE AND FEDERAL PIPELINE SAFETY REGULATIONS: IMPLICATIONS FOR TODAY'S NATURAL GAS PIPELINE SYSTEM

VOLUME I: TECHNICAL REPORT

Prepared by:

T. M. Shires
M. R. Harrison
Radian International
P.O. Box 201088
Austin, Texas 78720-1088

802377.01

Prepared for:

GAS RESEARCH INSTITUTE
Contract No. 6032

GRI Project Manager
Dr. Keith Leewis
Transmission Business Unit

December 1998

GRI DISCLAIMER

LEGAL NOTICE: This report was prepared by Radian International as an account of work sponsored by the Gas Research Institute (GRI). Neither GRI, members of GRI, nor any person acting in behalf of either:

a. MAKES ANY WARRANTY OR REPRESENTATION, EXPRESS OR IMPLIED, WITH RESPECT TO THE ACCURACY, COMPLETENESS, OR USEFULNESS OF THE INFORMATION CONTAINED IN THIS REPORT, OR THAT THE USE OF ANY INFORMATION, APPARATUS, METHOD, OR PROCESS DISCLOSED IN THIS REPORT MAY NOT INFRINGE PRIVATELY OWNED RIGHTS, OR

b. ASSUMES ANY LIABILITY WITH RESPECT TO THE USE OF, OR FOR ANY AND ALL DAMAGES RESULTING FROM THE USE OF, ANY INFORMATION, APPARATUS, METHOD, OR PROCESS DISCUSSED IN THIS REPORT.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
December 1998

3. REPORT TYPE AND DATES COVERED
Topical: June 1998 – December 1998

4. TITLE AND SUBTITLE
Development of the B31.8 Code and Federal Pipeline Safety Regulations:
Implications for Today's Natural Gas Pipeline System

5. FUNDING NUMBERS
Contract No. 6032

6. AUTHOR(S)
Theresa M. Shires and Matthew R. Harrison

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Radian International
8501 N. Mopac Boulevard
P.O. Box 201088
Austin, Texas 78720-1088

8. PERFORMING ORGANIZATION REPORT. NO.
DCN 99.802377.01

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Gas Research Institute
8600 West Bryn Mawr Avenue
Chicago, Illinois 60631

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
GRI-98/0367.1

11. SUPPLEMENTARY NOTES
Dr. Keith Leewis
Transmission Business Unit

12a. DISTRIBUTION/AVAILABILITY STATEMENT

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

This report documents the intentions and founding principles of the ASME B31.8 Gas Transmission and Distribution Piping Systems Codes and the Pipeline Safety Regulations (Title 49 Code of Federal Regulations Part 192). Two meetings were held with distinguished pipeline experts and the first directors of the Office of Pipeline Safety to provide background information on the development of the Codes and Regulations. The focus of this effort was natural gas transmission pipeline operations. This report also addresses five major topics of interest to the U.S. transmission pipeline industry: establishing the threshold for operating pressure, class location areas, valve spacing, inspection frequencies, and public communications. Through an understanding of the Code and regulatory foundations, the pipeline industry can more effectively interpret and apply the requirements and recommendations to today's natural gas pipelines. In addition, the industry can use this information to support continued public benefit, improved safety, and industry growth.

14. SUBJECT TERMS
Natural gas industry, Pipeline, B31.8, Code, Regulation

15. NUMBER OF PAGES
184

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	

NSN 7540-01 280-5500
Standard Form 298 (Rev. 2-89)
Prescribed by AN SI std. Z39-18 298-102

RESEARCH SUMMARY

Title	Development of the B31.8 Code and Federal Pipeline Safety Regulations: Implications for Today's Natural Gas Pipeline System
Contractor	Radian International GRI Contract No. 6032
Principal Investigator	Theresa M. Shires and Matthew R. Harrison
Report Period	June 1998 through December 1998
Objective	To document the early development of the ASME B31.8 Code and federal Pipeline Safety Regulations so that current and future pipeline engineers can understand the basis of these industry standards and regulatory requirements.
Technical Perspective	The B31.8 pipeline industry Code and the Title 49 CFR Part 192 regulatory requirements have evolved over time based on technological developments and engineering advances, as well as political and operational philosophies. Current pipeline Code and Regulations differ significantly from the original documents. An understanding of the Code and regulatory foundations is necessary to interpret and apply these requirements to today's natural gas pipeline systems in the interest of safer and more efficient pipelines.
Technical Approach	Two meetings were held with a number of distinguished pipeline experts to discuss the development of the original B31.8 gas pipeline Code. In addition, the first directors of the Office of Pipeline Safety joined in this effort to provide background on the federal Pipeline Safety Regulations. The focus of this effort was natural gas transmission pipeline design, construction, and operations. Discussions covered the founding principles of the B31.8 Code and the federal Regulations and addressed the following five major topics of interest to the pipeline industry: 1) establishing the bases for operating pressure; 2) class location areas; 3) valve spacing; 4) inspection frequencies; and 5) public communications.
Results	This report presents a compilation of information and discussions with founders of the B31.8 Code and federal Pipeline Safety Regulations. The two group meetings were video taped for archival purposes.
Project Implications	The results of this study provide the natural gas industry with a greater understanding of the founding principles and intentions of the B31.8 Code and federal Pipeline Safety Regulations. Industry can use this information to support continued public benefit, improved safety, and industry growth. GRI Project Manager Dr. Keith Leewis Transmission Business Unit

Table of Contents

Page

1.0 INTRODUCTION **1**
- 1.1 GRI INITIATIVE 1
- 1.2 PARTICIPANTS 1
- 1.3 REPORT STRUCTURE 1

2.0 HISTORY OF B31.8 .... **1**
- 2.1 BACKGROUND 1
- 2.2 B31.8 1
- 2.3 THE PIPELINE RESEARCH COMMITTEE 2

3.0 PIPELINE SAFETY REGULATIONS **1**
- 3.1 TECHNICAL PIPELINE SAFETY STANDARDS COMMITTEE 2
- 3.2 PHILOSOPHY 2
- 3.3 ADOPTING INDUSTRY STANDARDS AS REGULATIONS 3
- 3.4 ROLE OF B31.8 AND INDUSTRY 3
- 3.5 THE RESURRECTION OF THE B31.8 CODE 4

4.0 ESTABLISHING THE THRESHOLD FOR OPERATING PRESSURE **1**
- 4.1 ESTABLISHING OPERATING PRESSURE 1
- 4.2 WALL THICKNESS 2
- 4.3 STEEL CHARACTERISTICS 2
- 4.4 EARLY TESTING PRACTICES 2
- 4.5 REGULATORY REQUIREMENTS 3

5.0 CLASS LOCATION AREAS **1**
- 5.1 1955 CODE COMMITTEE 1
- 5.2 SUBSEQUENT CHANGES BY THE B31.1.8 COMMITTEE 2
- 5.3 DOT CHANGES 3

6.0 VALVE SPACING **1**
- 6.1 CODE CONSIDERATIONS 1
- 6.2 REGULATORY REQUIREMENTS 1

7.0 INSPECTION FREQUENCIES **1**
- 7.1 CODE CONSIDERATIONS 1
- 7.2 REGULATORY REQUIREMENTS 1

8.0 PUBLIC COMMUNICATIONS **1**
- 8.1 CODE CONSIDERATIONS 1
- 8.2 REGULATORY REQUIREMENTS 1

9.0 CONCLUSIONS **1**

10.0 REFERENCES **1**

ACKNOWLEDGEMENTS **11-1**

APPENDIX A: MEETING PARTICIPANTS **A-1**

APPENDIX B: 1955 B31.1.8 COMMITTEE MEMBERS* **B-1**

APPENDIX C: THE REGULATORS' HANDBOOK* **C-1**

APPENDIX D: OPS DOCKETS* **D-1**

APPENDIX E: MAOP BACKGROUND AND HISTORY **E-1**

APPENDIX F: ARTICLES BY F. A. HOUGH ON THE ASA CODE B31.1 SECTION 8 .... **F-1**

* Re-typed for clarity.

LIST OF TABLES

Page

Table 5-1. B31.1.8 Design Factors 3
Table 6-1. B31.1.8 Valve Spacing Requirements 1

1.0 Introduction

1.1 GRI Initiative

Although the Code may appear to be explicit, the interpretation of the Code, particularly that which is incorporated into Title 49 of the Code of Federal Regulations Part 192 (49 CFR Part 192), is not as clear-cut. The Code documents standards that were developed from years of operating experience and empirical data. The Code is the fruit of a significant work commitment by engineers to reduce complexities into simple practice. Prior studies by Mr. Bob Eiber and Mr. Wes McGehee examined the intent of the regulatory requirements (McGehee, 1998; Eiber, 1997), but these documents are not publicly available and contained topics where cited reference information could not be located.

The Gas Research Institute (GRI) sponsored an initiative to prepare a summary of the development of the original American Society of Mechanical Engineers (ASME) B31.8 Gas Transmission and Distribution Piping Systems Code. The 1968 edition of the Code was used by the Office of Pipeline Safety (OPS) as a basis for issuing the federal Pipeline Safety Regulations as embodied by 49 CFR Part 192. The purpose of this initiative was to document the early Code and regulatory developments so that current and future pipeline engineers can understand the basis and logic used in establishing the requirements. To meet this objective, retired pipeline experts and the first two directors of OPS joined in this effort to provide information.

1.2 Participants

Through two meetings, some of the founders of the B31.8 Code and 49 CFR Part 192 gathered to recall and describe the Code and regulatory development. Appendix A lists pipeline *emeritus,* former OPS staff, and others who participated.

1.3 Report Structure

In comparing the current (1995 Edition)[1] B31.8 Code to the 1955 version, many significant revisions and/or additions have been made over the years. These include:

- Requirements for the transportation of pipe;
- Provisions for the reuse of pipe;
- Provisions for fracture control and arrest;
- Provisions for brittle fracture control;
- Design and testing requirements to allow operation of pipeline up to 80 percent of SMYS;
- Replacement of the “type construction” concept with design factors for class location;
- Provisions for plastic pipe;
- Requirements for written emergency procedures;
- Liaison with public, fire, police, and other public officials;
- Requirements for education programs;
- Chapter on corrosion control;
- Chapter on offshore pipelines;
- Fabrication details (new appendix);

[1] The 1998/99 version is being finalized.

- Criteria for cathodic protection (new appendix);
- Development of a Supplemental Standard (ASME B31G *Manual for Determining the Remaining Strength of Corroded Pipelines)*;
- Gas leakage control criteria (new appendix); and
- Recommended practice for hydrostatic testing of pipelines in place (new appendix).

This document addresses the development of the B31.8 Code (Section 2) and the foundations of the Pipeline Safety Regulations (Section 3). Although the Code and Regulations were developed for application to gathering, transmission, and distribution pipelines, the focus of this analysis is on natural gas transmission pipeline design, construction, and operations.

In addition, this document addresses five major topics of interest to the pipeline industry:

1. Maximum Allowable Operating Pressure (MAOP) (Section 4);
2. Class Location (Section 5);
3. Valve Spacing (Section 6);
4. Inspection Frequency (Section 7); and
5. Public Communication/Education (Section 8).

Conclusions are presented in Section 9, and Section 10 provides references. The appendices provide a list of meeting participants, a list of the 1955 B31.1.8 committee members, and reprints of some founding documents from the development of the Pipeline Safety. The appendices also include the draft final report *Maximum Allowable Operating Pressure (MAOP) Background and History* (McGehee, 1998), which led to the resolve to initiate this report.

The meeting proceedings were videotaped to aid in documenting the discussions. A single copy is archived in GRI's library. The set includes:

B31.8 Discussion
June 25, 1998
Volume 1: Overview and Introductions
Topic 1: Establishing MAOP
57:00 minutes

Volume 2: Topic 2: Class Location Areas
Topic 3: Valve Spacing
Topic 4: Inspection Frequencies
Topic 5: Public Education
114:32 minutes

Transition of B31.8 to 49 CFR 192
August 20, 1998
Volume 1: Topic 1: Review of June Meeting
Topic 2: Discussion on 49 CFR Part 192
144:30 minutes
Volume 2: Topic 3: Gas Piping Technology Committee
Topic 4: Current Industry Issue
45:40 minutes

In addition, Volume 2 of this report provides a transcription of the meeting discussions.

2.0 History of B31.8

2.1 Background

The private development of material standards and performance codes preceded governmental regulations of this nature by several decades. For the pipeline industry, the need for a national pressure piping code became increasingly evident from 1915 to 1925. In March of 1926, the American Standards Committee (later changed to the American Standards Association and currently the American National Standards Institute) initiated Project B31 at the request of the American Society of Mechanical Engineers. After several years work by Sectional Committee B31 and its subcommittees, the first edition of the Code was published in 1935 as an American Tentative Standard Code for Pressure Piping. It covered pressurized piping for power, gas, air, oil and district heating. Following incorporation of refrigeration in the scope, it was published in 1942 as the American Standard Code for Pressure Piping. Additions and/or supplements to this Code were published in 1944, 1947, and 1951.

Another factor in the development of pipeline Code was congressional interest in pipeline safety in the early 1950's. As a result of 1947 eminent domain legislation and two relatively obscure pipeline incidents in 1950, Congress began to focus on the issue of pipeline safety. Representative John W. Heselton of Massachusetts introduced a bill in the 81st Congress seeking to establish federal regulations covering natural gas pipelines (Congressional Research Service, 1986). This bill provided an impetus to the industry to develop its own safety code in order to forestall the need for congressional action.

2.2 B31.8

At its annual meeting on November 29, 1951, the B31 Standards Committee authorized subdividing the Code and issuing a separate publication of a natural gas section for gas transmission and distribution piping systems. The purpose was to provide an integrated document for gas transmission and distribution piping that would not require cross referencing other sections of the Code (ASME, 1995). The stand-alone gas Code was issued in 1952 as ASA B31.1.8: *American Standard Code for Pressure Piping, Section 8, Gas Transmission and Distribution Piping Systems*. It consisted almost entirely of material taken directly from Section 2 (Gas and Air Piping), Section 6 (Fabrication Details) and Section 7 (Materials) of the 1951 Edition of the Pressure Piping Code.

Later in 1952, a completely new B31.1.8 Committee was formed to update the Section 8 Code so that it more adequately covered all aspects of pipelining. This update incorporated new materials and new design, construction, and testing methods that were rapidly being developed. The new Committee was chaired by Mr. Fred Hough, Vice President of Southern Counties Gas Company in Los Angeles. The Committee consisted of representatives from transmission and distribution companies, the public through the participation of the Federal Energy Regulatory Commission (FERC) and state utility commissioners, pipe and equipment manufacturing companies, and other technical experts.

The Committee's first meeting was held in Chicago in 1952. The Committee organized itself into a number of subgroups, each responsible for preparing a particular section of the Code. There were many meetings held over time, with 125 to 130 attending members and support people. Over a period of two and a half years, as preparation of the new Code material proceeded, many diverse opinions were expressed and many parts of the Code received extensive argument and discussion before final agreement. This discourse, plus input from a number of research programs, contributed to producing a

realistic Code that represented generally accepted and safe practices. The new Code document was published in 1955 as ASA B31.1.8 Gas Transmission and Distribution Piping Systems.
The intent was for the Code to be a compendium of good design, construction, operation, and maintenance practices. The industry's objective was to make a major contribution to the improvement of public safety by understanding the causes of failures and establishing guidance, procedures, and methods for reducing pipeline failures. As a secondary objective, the Code was developed with the intent that, if necessary, it could be adopted by reference into a regulatory framework (Hough, 1954).

A series of articles written by Mr. Fred Hough and published in *GAS* magazine starting in November, 1954, provide insight into the intentions and reasoning of the Committee in preparing the Code. Some excerpts from these articles follow (Hough, 1955).

- "The requirements of Section 8 are adequate for safety under conditions normally encountered in the gas industry. Requirements for abnormal or unusual conditions are not specifically provided for, nor are all details of engineering and construction prescribed. It is intended that all work performed within the scope of this Section shall meet or exceed the safety standards expressed or implied within."

- Since the Code states what is generally accepted as good practice, it does not include good practices that are not generally accepted. As a result, "superior practices, which under some conditions at least are highly desirable, are not prescribed in the Code."

- The Code was not written to be used as a specification. "A specification is intended to fully describe a material or piece of equipment and to specify the tests and tolerances to be applied to determine whether a given sample fits the description accurately." Rather, the Code prescribes conditions of use to which items complying with standard specifications can be applied.

In 1958, further revisions were published as ASA B31.8 - 1958.

The strength of the original Code is reflected in the fact that B31.8 was adopted by all of the state agencies that had authority to regulate gas pipeline safety and also was adopted by many countries throughout the world. The B31.8 Code has also contributed to the worldwide growth of the pipeline industry by providing standards that, when followed, result in an acceptable level of safety.

As each generation of the Code Committee brings new ideas and advances in technology, the industry Code has continued to evolve to reflect changes in practices, solutions to emerging safety problems, and new technologies.

2.3 The Pipeline Research Committee

The Pipeline Research Committee (PRC) has played an important role in the development of the B31.8 Code provisions. PRC was formed in 1952 at the suggestion of the B31.1.8 Code Committee to pool industry research funds to address the issue of long running brittle fractures. The results of this initial effort were well received by the industry, and the PRC continued to pursue other cooperative research needs funded by the pipeline industry under agreement with the American Gas Association (A.G.A.).

The mission of the PRC*I*[2] is to sponsor and direct basic and applied research aimed at optimizing all technical aspects of the natural gas transmission industry and its related activities. In an effort to direct a concentrated research program, PRC*I* operates under the following objectives:

1. Provide for the definition and systematic resolution of all major technical problems faced by industry;
2. Promote the development of new ideas, methods, procedures, and equipment to improve existing design and construction practices, and the continued safe operation of existing and future pipeline facilities;
3. Sponsor training, seminars, and symposiums, and prepare technical reports to inform industry operators, technicians, and engineers on current and pertinent research results; and
4. Encourage meaningful additions to governing codes, regulations, and specifications in the interest of safer and more efficient pipelines.

PRC*I* has funded a wide variety of research efforts aimed at these objectives. Some of the research efforts include:

- Underbed cracking during welding;
- Welded branch connection design;
- Secondary stresses in pipelines;
- Brittle fracture control and prevention;
- Cyclic stresses during rail shipment of pipe;
- High-pressure hydrostatic testing;
- Hydrogen cracking;
- Stress corrosion cracking;
- Ductile fracture arrest;
- Fracture initiation;
- Definition of defect severity;
- Defect repair methods;
- Strength of corroded areas;
- Inline inspection methods;
- Surveys of causes of service failures;
- Failure investigations; and
- Symposia to disseminate research results to industry.

These research efforts vary from small, short duration projects to large, multi-year programs. The results of many of the programs were used directly in preparing Code material. The results from a few programs led to specifications or recommended practices published in other documents and referenced in the Code.

[2] In 1996, the PRC adopted the name Pipeline Research Committee *International* (PRC*I*) to better reflect its current membership, which consists of about 15 major U.S. natural gas companies and 15 international members.

3.0 Pipeline Safety Regulations

One of President John F. Kennedy's campaign promises in the 1960 election was a broad commitment to consumer safety (Congressional Research Service, 1986). The interest of the federal government in consumer protection was not new, but the 1960's brought about a recognition of the consumer's "right to safety." President Lyndon B. Johnson reiterated the consumer interest message in 1964 and specifically called attention to pipeline safety in his 1967 State of the Union Address:

> "We should immediately take steps to prevent massive power failures, to safeguard the home against hazardous household products and to assure safety in the pipelines that carry natural gas across our Nation…" (Congressional Research Service, 1986).

The Natural Gas Pipeline Safety Act, enacted on August 12, 1968, established exclusive federal authority for safety regulation of interstate transmission lines. It also established non-exclusive federal authority for safety regulation of gathering lines in non-rural areas and intrastate transmission and distribution pipelines (Docket OPS-3, 1970). It did not include gas production or related processing facilities.

The Pipeline Safety Act gave the Secretary of Transportation broad powers to develop and publish federal standards applicable to the design, construction, operation, and maintenance of facilities used in the transportation of natural (and other) gas. It also required the Secretary of Transportation to adopt, within three months, interim regulations, and within 24 months to establish minimum federal safety standards. The regulations were to establish minimum safety standards for all phases of the design, construction, maintenance, and operation of gas pipeline facilities.

The Office of Pipeline Safety (OPS) was formed to administer the Pipeline Safety Act and to serve as a clearinghouse for safety information. A role assigned to OPS was to investigate system failures, research the causes of failures, define safety problems, and seek solutions to those problems. Prior to this, there were no reporting requirements for gas pipeline accidents. A study was initiated in 1968 to begin gathering pipeline incident data and to develop the first incident reporting form. This study established a data management system and incident reporting format to record information on incidents in a consistent manner and was used to establish a uniform guideline for the investigation of pipeline failures. The study revealed that the most significant problem faced by pipeline operators, with respect to pipeline incidents, was excavation damage, particularly that caused by outside contractors (third parties). One of the purposes of this data collection effort was to compare operating practices and system failures to determine if a relationship could be developed between certain practices and failure modes.

The regulatory process consists of collecting information to define safety problems. Once problems are defined, alternative solutions are evaluated, and the best alternatives are published as a notice of proposed rule making. The public is given an opportunity to comment on the notices for a pre-established time period. In developing the 49 CFR Parts 190 and 192 Federal Safety Standards, over 500 separate comments, totaling 2,500 pages were received in response to the notices of proposed rulemaking (Docket OPS-3, 1970). The industry itself filed over 80 petitions to change 49 CFR Part 192 between the time the federal rules were issued and 1973.

After written and oral comments are received and evaluated, a regulation is drafted. For the Pipeline Safety Regulations, the Technical Pipeline Safety Standards Committee (TPSSC) was requested to review the proposed regulations and provide comments to OPS.

3.1 Technical Pipeline Safety Standards Committee

The Natural Gas Pipeline Safety Act of 1968 required the establishment of a 12-member TPSSC. This committee was appointed by the Secretary of Transportation to advise the Director of OPS on all proposed standards and amendments. The committee is required to prepare a report on the technical feasibility, reasonableness, and practicability of all proposed regulations. Since TPSSC had extensive pipeline knowledge and background, the OPS Director sought the committee's counsel on a variety of subjects beyond this required function, including reliance on the committee for technical and operational guidance throughout the development of the regulations. The OPS Director acknowledged that the regulations could not have been written within the two-year time frame set by Congress without the active technical assistance of the committee and especially the industry members.

The original TPSSC consisted of four industry experts, six public representatives, and five government officials. The members were selected to provide a balance of skill and knowledge by selecting representatives with specialized knowledge in each of the elements that make up pipeline operations. Although representatives from industry were members of the committee, their primary function was to provide technical expertise. On this committee, all members worked for the government and in the interest of the public. At the time, the committee members were offered compensation for their participation because OPS wanted the members to feel an obligation toward their role in the regulatory development and not to serve as representatives of their employers. The industry members declined the offer.

The TPSSC report on the original Minimum Federal Safety Standards under Parts 190 and 192 expressed concern that much work remained to be accomplished in future rulemakings to clarify the rules and to further improve the safety of pipeline facilities. Considering all aspects affecting safety was beyond the scope of the original time frame allotted to develop the regulations. The committee concurred on the final rule, but relied on assurances that supplemental rulemaking dockets would provide for further regulatory action in specific areas.

3.2 Philosophy

The pipeline industry was fortunate in that the original Pipeline Safety Regulations reflected the values and integrity of the first OPS Director, Mr. William Jennings. Mr. Jennings' philosophies and intentions shaped the regulations into a form that served the interest of both the public and the government, while preserving the support of the pipeline industry.[3] Mr. Jennings believed a regulation is a solution to a problem. He stated that without a well-defined problem, there is no need for a regulation. As such, problem definition is essential to developing the solution. Mr. Jennings felt that the regulator does not create abstract regulations in a social vacuum. Rather, he should seek regulatory solutions to problems as they are seen in light of the current social environment.

Some of the distinguishing considerations built into the regulatory development process, under Mr. Jennings' direction, include the following:

> **Relationship between cost and benefit** – The purpose of the regulations was to establish a standard of safety that would be acceptable to the populace at large. The cost/benefit aspect is not a mathematical formula, but rather a state of mind which considers both cost and benefit in

[3] More details on Mr. Jennings philosophy in developing the pipeline safety regulations are provided in a book that Mr. Jennings authored based on his experience in regulatory development. The document is provided in its entirety in Appendix C.

evaluating regulatory proposals, seeking to minimize the hazard to the public within the limits of economic feasibility.
Public participation – The development of regulations is a political process, balancing the needs of Congress, the public, and industry. Regulatory agencies perform a public function, and the participation of the public contributes to the validity of the regulatory process. Facts are best tested and conclusions best validated through the clash of opposing opinions. The pipeline safety regulatory process was open to the public, inviting public input at all steps and on all subjects. The public was provided ample opportunity to participate in the identification and definition of safety problems, the development of alternative solutions, and the choice of regulatory solutions (where regulation is appropriate).

Performance language – To the extent possible, the regulations were to be stated in terms of performance standards rather than design and construction specifications. That is, the regulations prescribe what industry must do to achieve adequate safety by stating the level of performance that must be met. Tests and analytical procedures are prescribed to measure performance.

3.3 Adopting Industry Standards as Regulations

Mr. Jennings and his staff could have adopted the B31.8 Code as the regulations, but Mr. Jennings believed that regulations should be developed by government, not industry.[4] However, he adopted the B31.8 Code as the interim regulations, pending publication of the new regulations. The Code was then used as a guide in developing the new regulations.

Regulations differ significantly in both format and function from industry standards. Regulations prescribe what industry must do, while industry standards recognize and recommend practices which experience has shown to be safe. The standards themselves become recommended practices, with no legal requirement for compliance.

Industry standards are developed by industry members, based on cumulative technical knowledge and experience, for the benefit of the industry. By adopting industry standards as regulations, the regulator in effect designates that which was designed as a recommendation to become a legal requirement. Any new or different proposal requires a one time exception or waiver. Therefore, the regulator controls the ingenuity and initiative of the industry in developing new technology and techniques, while industry standards encourage innovation and new technology.

3.4 Role of B31.8 and Industry

OPS sought a cooperative relationship with the industry, founded on the mutual interest of safety, and drawing on the experience and talent of industry. However, industry cooperation was not to be pursued at the price of a weak regulatory program or to the extent that the collaboration would be viewed by Congress as industry writing their own regulations.

The B31.8 Code was widely used, maintained, and developed during the 15 years before Congress passed the Pipeline Safety Act. With the publication of 49 CFR Part 192, the role of the B31.8 Committee was significantly diminished because they did not want to become an auxiliary to the federal rules group. 49 CFR Part 192 essentially replaced the B31.8 Code as the safety standard for U.S. gas pipeline operators.

[4] Mr. Jenning's explains the reasons for this belief in Chapter 14 of *The Regulator's Handbook*, provided in Appendix B of this report.

As a result, the U.S. gas pipeline industry lost interest in maintaining the B31.8 Code and turned its attention toward interpretation of the regulations. At this point, activities of the B31.8 Code Committee ceased.
It was agreed that, upon publication of 49 CFR Part 192, a document, entitled *Guide for Gas Transmission Piping Systems,* would be created, containing information that gas pipeline operators could use to comply with the provisions of the Pipeline Safety Regulations. A recommended means of compliance with each requirement of 49 CFR Part 192 was developed by the Gas Piping Standards Committee (later renamed the Gas Piping Technology Committee, GPTC), a group formed from the membership and leadership of the B31.8 Committee. The *Guide* was initially sponsored by the American Society of Mechanical Engineers (ASME) and later approved as an American National Standard and given the designation of ANSI/GPTC Z380. The *Guide* is revised each time there is a change to 49 CFR Part 192.

The *Guide* was, and is, intended to be useful to pipeline operators in their efforts to meet the 49 CFR Part 192 requirements. For all practical purposes, U.S. gas pipeline operators at the time regarded the GPTC and the *Guide* as replacing the Code Committee and the B31.8 Code. The B31.8 Committee went into limbo during the 1970 to 1971 period. The industry did not believe that maintaining the Code in accordance with changing technology would serve any useful purpose since the industry could not use the new technology until it was incorporated into the regulations.

3.5 The Resurrection of the B31.8 Code

In the early 1970's, Phillips Petroleum Company was planning to construct a gas pipeline from its production facilities in the North Sea to the Norwegian mainland. The Norwegian government requested that Phillips provide the rules or code that would be followed in designing and constructing the pipeline. The oil company replied that it would follow the requirements of the B31.8 Code. During this process, it was discovered that if the B31.8 Code was not revised or reaffirmed by 1974, ASME rules required that it would cease to exist. The need for an international code was brought to the attention of the gas pipeline industry, and the B31.8 Code Committee was reactivated to reaffirm the Code and to develop procedures for offshore pipelines.

The Committees that oversee the *Guide* and the B31.8 Code are both very active in maintaining the status of their respective publications. The *Guide* is useful only for facilities that are subject to regulatory sections under the jurisdiction of the U.S. DOT. The B31.8 Code is applicable to pipeline facilities transporting gaseous fluids anywhere in the world and contains an entire chapter on offshore pipelines. For U.S. gas pipeline operations, except for rural gathering systems, the regulatory requirements of 49 CFR Part 192 take precedence over the Code.

4.0 Establishing the Threshold for Operating Pressure

4.1 Establishing Operating Pressure

Pipe for a particular line is generally purchased to a specified minimum yield strength (SMYS).[5] Operating pressure is then set lower than SMYS to incorporate a safety factor. A minimum design factor of 72 percent of SMYS was derived from the first all welded pipeline, installed by Natural Gas Pipeline Company of America in the 1930's. Because the use of an all-electric girth welded line was new, no precedent existed for operating pressure. It was determined that the pipe could be used safely at a stress level of 80 percent of the manufacturer's mill test pressure (typically 90 percent of SMYS), where 80 percent of the 90 percent of SMYS results in a maximum allowable operating pressure (MAOP) of 72 percent of SMYS. A 72 percent stress level first appeared in the 1935 American Tentative Standard Code for Pressure Piping. To establish a consistent basis for MAOP, the 1935 Committee agreed that mill test pressure would be that basis. This became an established practice and was proven safe through operation, and was thus accepted by the early Code Committee as the basis for establishing MAOP. Post testing was not an industry practice at the time the 72 percent of SMYS was selected. Only a gas leak test was performed. The only strength test conducted was the mill test.

It is important to note that at that time (1935) API Standard 5L (currently referred to as API Specification 5L) did not require line pipe to be tested to 90 percent of SMYS. Grade B pipe, for example, which has a SMYS of 35,000 pounds per square inch (psi), was required to be tested by the manufacturer to a hoop stress level in the range of 16,000 to 18,000 psi (about 50 percent of SMYS). However, by agreement between the purchaser and the manufacturer, some manufacturers were willing to test each piece of pipe to a level of 90 percent of SMYS. When the API 5LX specification (for the higher strength X grades) first appeared as a tentative specification in 1949, the standard mill test pressure level was established at 90 percent of SMYS. So, while the 72 percent of SMYS stress level was based on 80 percent of a mill test pressure equal to 90 percent of SMYS, it was not certain that all pipe made before 1949 was mill tested to 90 percent of SMYS. It was subsequently revealed that the vast majority of the mileage of natural gas pipelines in the United States was installed after 1949 when the 90 percent of SMYS from hydrostatic test by the pipe manufacturer became the norm.

The B31.1.8 Committee examined many pipelines in the United States while developing recommendations for operating pressure. Many of the members traveled across the country to look at how pipelines were built and operated. Some operators were using 80 percent of the actual yield strength established by hydrostatic testing, while others were field testing to much lower pressures. The end conclusion was to maintain the long established practice of using 80 percent of the 90 percent mill test pressure, resulting in an allowable maximum hoop stress of 72 percent of SMYS because it was proven to be safe through operational experience. The industry was under significant political pressure at the time, due to consideration of the Heselton Bill in Congress. So, they relied on the established experience, believing that they could defend it politically and because it did not penalize existing operations.

It should be noted that, although the maximum operating hoop stress in a natural gas pipeline was set at 72 percent of the SMYS from the pipe purchase contract, other sections of B31 based the allowable stresses on the minimum ultimate tensile strength (UTS). Design based on tensile strength, especially if done in the manner specified by the other B31 piping codes, would have been unnecessarily restrictive.

[5] The actual yield strength almost always exceeds SMYS, sometimes by as much as 15,000 psi.

4.2 Wall Thickness

In addition to using SMYS instead of tensile strength in determining MAOP, the gas industry also used nominal (or specified) wall thickness instead of minimum wall thickness in determining MAOP. At the time B31.1.8 was written, seamless pipe was widely used. The under-thickness wall tolerance for seamless pipe was much larger than pipe made from plate with a welded longitudinal seam. The industry did not want to specify wall thickness based on the seamless under-thickness wall tolerance. Basing pipeline operation on nominal wall thickness for 72 percent of SMYS accounted for operation with both seamless and plate pipe, and was justified through safe historical operation.

4.3 Steel Characteristics

Prior to 1949, the API Standard 5L covered steel Grades A, B, and C and other materials such as wrought iron. Grade C, the highest strength steel grade (SMYS = 45,000 psi), was discontinued in the 1930s and Grade B (SMYS = 35,000 psi) became the highest grade mentioned. However, purchasers could, and often did, obtain line pipe materials with SMYS levels above 35,000 psi by negotiation. For example, in building the original Tennessee Gas system (October 31, 1943) the SMYS that could be produced by a manufacturer for this system was 50,000 psi. A special steel alloy and plate rolling procedure were required to reach this strength level. At the time, the average actual yield strength of most of the pipe produced was 47,000 psi.

In 1949, the first tentative X-grade specification, API Standard 5LX, appeared. This specification provided requirements for Grade 5L X42 only (SMYS = 42,000 psi), but it stated that requirements for higher grades could be negotiated. Over time, the strength improved with better alloying and rolling techniques. By 1954, specific requirements for cold-expanded and non-expanded pipe in Grades X42, X46, and X52 were included in API Standard 5LX.

4.4 Early Testing Practices

A pre-service integrity validation by pressurizing the pipeline to a level above the maximum operating pressure was a method of insuring the reliability of pressure vessels. This safety practice was always an important part of the ASME Boiler and Pressure Vessel Code. Prior to the 1955 B31.1.8 Code, however, the post-construction/pre-operation test requirements for gas transmission and distribution piping stated that the line must be capable of withstanding a test pressure 50 psi higher than the maximum pressure at which the line is to be operated.

For early testing practices, gas was the common test medium. Proof testing with water is safer, since a rupture during a gas test can be very dangerous. Although proof testing with water was used in other industries, its use was very limited in the pipeline industry. The volume of water required to pressure test pipelines and the transportation of the water made hydrostatic testing prohibitively expensive and impractical, particularly in the climatically dry areas of the United States where many of the first long distance gas pipelines were constructed. In addition, operating problems may result if the water is not removed from the pipeline.

The use of natural gas as the test medium limited the test pressure that could be achieved because operators were reluctant to raise the pressure much higher than the expected operating pressure. One gas company recalled that they thought they had done well if they could reach a pressure of five or ten psi over the operating pressure. This was a potentially dangerous practice for the operators. When a pipe

failure was initiated during gas testing, the potential energy and slow decompression of the natural gas would drive long, brittle-type pipe fractures.
The practice of hydrostatically testing pipelines to yield was initiated by Texas Eastern Transmission Corporation.[6] Texas Eastern had purchased two pipelines from the federal government, a 20-inch products line and a 24-inch crude line (also known as the Little- and Big-Inch pipelines), and converted them to natural gas. In the late 1940s, a number of pipeline incidents occurred on these lines, such that Texas Eastern's insurance carrier threatened to cancel coverage unless a program was developed to prevent further pipeline system failures. To verify integrity, Texas Eastern elected to test all of the 20-inch pipeline.

High-pressure hydrostatic testing was further examined by Battelle under the sponsorship of Texas Eastern and A.G.A.'s PRC over the time period from 1953 through 1968 (Duffy, 1968). This program examined test results from hundreds of miles of large diameter pipe using water as the test medium and at test pressures that would produce a transverse stress in the pipe wall equal to the SMYS. The benefits of hydrostatic testing documented by the program included:

- The ability to establish the real minimum strength of the pipeline as opposed to the mill tensile tests which are based on testing only about 1 percent of the pipe (to make this determination, the test must include a pressure/volume plot);
- The increased safety inherent in basing operation on an established minimum strength;
- The ability to remove significant defects originating in the plate mill, pipe mill, or during fabrication and installation; and
- The excellent service performance of lines tested to actual yield.

Participants in the program recommended that the allowable operating pressure should be set based on a percentage of the hydrostatic test pressure. They specifically recommended that the allowable operating pressure be set at 80 percent of the minimum hydrostatic proof test pressure when the minimum test pressure is 90 percent of SMYS or higher.

4.5 Regulatory Requirements

The Pipeline Safety Regulations (49 CFR Part 192) defined SMYS as the yield strength specified as a minimum in the pipe purchase order, keeping a consistent definition with the Code. However, for unlisted or unknown specifications, SMYS must be determined by tensile tests of the pipe.

When the 49 CFR Part 192 regulations were developed, the requirements for establishing operating pressure reflected those of the Code. However, the Code did not apply retroactively to existing pipelines. Based on comments from the Federal Power Commission and TPSSC recommendations, a grandfather clause was added to the regulations permitting the continued operation of pipelines at the highest pressure the pipelines had been subjected to in the five years prior to July 1, 1970.

---

[6] Baxter Goodrich, Vice President of Texas Eastern at the time, is given credit for this initiative.

5.0 Class Location Areas

5.1 1955 Code Committee

The 1952 edition of B31.1.8 allowed operation of a pipeline with a hoop stress of 72 percent of SMYS in all locations except those inside incorporated limits of cities and towns (Eiber, 1997). Within cities and towns, operators used heavier wall pipe to limit the maximum operating pressure to that which would produce a stress of 50 percent of SMYS. Unfortunately, the densely populated areas did not always align with the city limits. Many operators were specifying heavier wall pipe to reduce the stress level below 72 percent of SMYS in certain population areas and at road and railroad crossings, but the criteria were not uniform among operators (McGehee, 1998).

To address the complex problem of relating pipeline location to operating pressure and to re-examine the appropriateness of the 50 percent SMYS design limit for high population areas, the 1955 B31.1.8 Committee appointed a subgroup to study the problem. This subgroup flew over numerous pipeline routes with local gas company maps to examine the current practices of pipeline companies. Aerial photographs of all of the major pipeline companies in the country were used to determine population densities within the right-of-way along the routes.

The subgroup recommended that the width of the area for determining population density and defining pipeline construction and the right-of-way zone be one-half mile (i.e., a quarter mile on either side of the center line of the pipeline). This width was selected because a zone of this width was conveniently identified on typical aerial photographs used for locating pipelines. In addition, the Committee believed that this width provided a representative sample of the area traversed by a pipeline and especially the activity occurring around the pipeline.

The number of buildings intended for human occupancy within this half-mile zone was examined. A statistical compilation of the population densities within a quarter-mile of the pipelines determined that a house count of approximately 20 dwellings per one-mile length would have a negligible effect on the majority of the existing pipeline systems. In fact, less than 5 percent of the total transmission pipelines at the time were impacted by higher populations requiring stress levels below 72 percent of SMYS (McGehee, 1998). Due to heightened political pressure resulting from the Heselton Bill, the Committee agreed on a limit of 20 dwellings per mile as the maximum density for areas where 72 percent of SMYS is permitted. The Committee believed that this designation reflected the current practices of pipeline operators, was demonstrated safe based on current practices, and would be politically acceptable.

The Committee did not intend for this width to imply that the pipeline was unsafe in this area. Rather, as the number of houses around the pipeline increases, the expected activity near the pipe threatens pipeline integrity. The Code was based on the premise that if the design of the pipeline is adequate for the level of exposure of the pipeline to the public and the public to the pipeline, then an acceptable level of safety will be achieved.

In determining the population density near the pipe, it was not the intention of the Committee that the design or operating pressure of a pipeline be changed as soon as the house count exceeded the specified limit. The Code Committee examined the population within the half-mile zone at one-mile and ten-mile lengths to determine the potential for growth along the pipeline route. The resulting design limits developed for the Code included some provision for normal increases in population.

As a result of the population density study, the Code Committee established four class location types in the 1955 edition of the B31.1.8 pipeline Code. The class locations were designated to address the concerns of increasing potential damage to the pipeline due to population and nearby activities, as well as issues with the availability of heavier wall plate.[7] Increasing the wall thickness would provide additional safety if corrosion or increased third-party damage occurred in higher population areas. At a constant MAOP, the thicker pipe reduces the stress levels. Thicker pipe reduced the stress levels, and reduced stress levels increased the ability of the pipe to withstand limited pipeline damage without rupturing. The design identified the allowable hoop stress in certain locations. A survey of the industry conducted by the B31.1.8 Committee summarized failures and the corresponding stress levels and showed that, at the time, only one failure below a 50 percent stress level had resulted in a rupture.

The subgroup's review of current practices confirmed that there were many areas where pipeline operators chose to install heavier wall thickness pipe than that required for 72 percent of SMYS or operated at lower pressures. Results from the review indicated that the higher population areas were those typically served by distribution companies, which operated their pipelines at much lower pressures and less than 40% SMYS. By the time the transmission pipeline reached the city gate station, 50 or more miles from the last compressor station, the pipeline operating pressure dropped well below 72 percent of SMYS, and was often in the range of 35 to 40 percent of SMYS. The subgroup concluded that 50 percent of SMYS was appropriate for developed areas, but acknowledged that the pressure should be slightly lower for densely populated areas of high rises, such as downtown business districts.

The Committee maintained the original design factors of 72 percent of SMYS and 50 percent of SMYS, and added two new designations. A stress level of 60 percent of SMYS was added to account for areas between rural and urban and to address suggestions about using a heavier wall pipe for road and railroad crossings, as well as valve settings, drips, and other fabricated assemblies used in cross-country pipelines. For large cities, the Committee added a fourth class type, with a reduced stress level of 40 percent of SMYS, to address the greater potential for damage to the pipeline in these areas and because most of the pipelines installed in densely populated areas were currently operated below 40 percent of SMYS. A description of the design factors corresponding to each construction type and class designation is shown in Table 5-1.

When the population increased, the Code allowed reclassification to the next lower class provided pipeline operators retested the pipe to 125 percent of MAOP if operating pressures were to be maintained. Otherwise, the pipeline pressure had to be reduced. This Code requirement was much more stringent than any previous document.

5.2 Subsequent Changes by the B31.1.8 Committee

In the early 1960's (before the Federal Pipeline Safety Act was being considered by a congressional committee), several of the northeastern state regulatory agencies (led by the New York Public Service Commission) brought to the attention of the B31.1.8 Committee that there were no provisions in the Code dealing with population growth along a gas pipeline. The Code Committee recognized that this could present a significant safety and credibility problem regarding both the B31.1.8 Code and the Code Committee. The Committee developed and approved best practice inspections to provide an engineering basis so the Code could address this problem in a timely manner. These provisions appeared in the 1968 edition of the Code (in Paragraph 850.4).

[7] At the time, the availability of steel meeting the desired wall thickness and strengths was greatly limited.

Table 0-1. B31.1.8 Design Factors

Design Factor (% of SMYS)	Construction Type	Applicable Location
72	A	• Private rights of way in Class 1 locations • Parallel encroachments on private roads or unimproved roads in Class 1 locations • Crossings without casings of privately owned roads in Class 1 locations • Crossings in casings of unimproved public roads, hard-surfaced roads, highways, or public streets and railroads in Class 2 locations
60	B	• Private rights of way in Class 2 locations • Parallel encroachments on private roads, unimproved roads, hard-surfaced roads, highways, or public streets and railroads in Class 2 locations • Crossings without casings of privately owned roads and unimproved public roads in Class 2 locations; or hard-surfaced roads, highways, or public streets and railroads in Classes 1 and 2 • Crossings in casings of hard-surfaced roads, highways, or public streets and railroads in Class 2 locations • Bridges in Class 1 and 2 locations • Fabricated assemblies in Class 1 and 2 locations
50	C	• Private rights of way in Class 3 locations • Parallel encroachments on private roads, unimproved roads, hard-surfaced roads, highways, or public streets and railroads in Class 3 • Crossings without casings of privately owned roads and unimproved public roads in Class 3 locations, or hard-surfaced roads, highways, or public streets and railroads in Classes 2 and 3 • Compressor station piping
40	D	• All locations in Class 4

5.3 DOT Changes

Although OPS adopted the basic concept of class locations and corresponding design factors from the 1968 B31.8 Code, it modified the method of determining population density and chose a right-of-way width of one-eighth mile on either side of the pipeline. The federal rules also made a corresponding change in the number of buildings intended for human occupancy and added other criteria to include places of public assembly.

An informal telephone survey conducted by OPS was the basis for reducing the width of the area right-of-way from a half-mile to a quarter-mile. The survey and a review of federal failure reports indicated that the half-mile zone was not necessary since impacts from past incidents had not extended even as far as a quarter-mile. Therefore, a quarter-mile wide zone, extending one-eighth of a mile on either side of the pipeline, was more appropriate. The OPS study considered both the impact of increased population on the pipeline within this corridor width, as well as the potential risk of a pipeline incident to people or buildings within one-eighth of a mile, and concluded that the reduction would not have an adverse effect on safety.

In reducing the corridor width for determining the population density by half from what the 1955 Code Committee had developed, OPS also reduced the number of dwellings from 20 to 10 for Class 1 locations. OPS further refined the other class designations as follows:

- Class 2 – Any one-mile section that has more than 10 but fewer than 46 buildings intended for human occupancy. Class 2 was intended to reflect areas between Class 1 and 3.
- Class 3 – Any one-mile section that has 46 or more buildings.
- Class 4 – Any one-mile section where buildings with four or more stories aboveground are prevalent.

These changes were later reflected in the 1974 revisions to the B31.8 Code.

The federal regulations also removed the 10-mile population density index and set the "class location unit" as a one-mile length. The regulations included a requirement for uprating the pipelines whenever the population increase resulted in a class location change. OPS originally proposed a 60-day period to confirm or revise the MAOP after a class change, but revised it to one year based on comments received from the notice of proposed rulemaking (NPRM). A second amendment was issued in September 1971, extending the time period to 18 months to comply with the requirements of the location class change.

6.0 Valve Spacing

6.1 Code Considerations

Pipelines in place and constructed at the time the B31.1.8 Committee was initially meeting were predominately located in rural areas. The typical valve spacing in these areas was 18 to 20 miles, with accessibility being the primary factor for selecting the valve location. Based on economical and operating convenience, valves were installed about 20 miles apart (on longer pipeline segments such as 100 miles) so that routine pipeline maintenance could be performed without having to blow the natural gas pressure down to one atmosphere and purge the methane with air for the entire pipeline between compressor stations. Some companies recognized the need for reduced distances in higher population areas, anticipating the need for more frequent isolation of valve sections to repair or replace pipeline defects.

Operating convenience, economics, and the need to limit adverse publicity during an incident were the primary motivations for establishing valve spacing recommendations in the Code. Although it is often perceived that valve spacing is based on minimizing the consequences of a pipeline incident, in actuality the majority of damage from a pipeline rupture occurs in the first few minutes (Sparks, 1995; Sparks, 1998). If the gas is ignited, being able to close the valve quickly has no effect on safety but may minimize negative public perception. Timely valve closure may not significantly reduce the amount of gas released to the atmosphere (Sparks, 1995, 1998). Safety is best addressed in the Code by assuring that the valve is accessible, and unexpected gas losses are minimized.

The Code Committee surveyed industry practice in 1955 and suggested a requirement for valve spacing as a function of class location, as shown in Table 6-1. Specific intervals were designated to satisfy concerns of potential litigation associated with specifying valve spacing based on engineering judgement. The Code Committee intended the valve spacing recommendations to be used as guidelines, but for pipeline operators to also consider local conditions. For example, a valve located near a roadway is more readily accessible than one located in the middle of a pasture, cornfield, or swamp.

Table 0-1. B31.1.8 Valve Spacing Requirements

Class Location	Valve Spacing
1	20 miles
2	15 miles
3	8 miles
4	5 miles

These spacing intervals reflected the current practices of the majority of pipeline operators in 1955, while also responding to governmental and public pressure for more valves in higher population areas.

6.2 Regulatory Requirements

The valve spacing requirements in 49 CFR Part 192 were based on recommendations in the B31.8 Code, but were rewritten to more clearly express the intended result (Docket OPS-3). The TPSSC believed that valve placement was primarily an economic matter rather than a safety consideration. The increased number of valves required for higher population areas was based on minimizing the volume of gas released during maintenance activities and was not a decision based on public safety.

1.1

7.0 Inspection Frequencies

7.1 Code Considerations

The question as to whether the Code should contain provisions regarding the operation and maintenance of pipeline systems received considerable attention by the B31.1.8 Committee (Hough, 1955). Because many of the state codes contained such provisions applicable to gas transmission and distribution facilities, the Committee decided that the Code must also include these requirements if it was to be accepted by the state and federal regulators. However, the Committee also believed that it would be impractical to include specific, detailed requirements in a national industry standard.

The 1955 B31.1.8 Code stated that each company shall meet the following basic requirements regarding operating and maintenance procedures:

1. Have a plan covering operating and maintenance procedures that meets the objectives of the Code;
2. Operate and maintain its facilities according to this plan;
3. Keep records necessary to administer the plan properly; and
4. Modify the plan as needed as exposure of the public to the facilities and operating conditions require (Hough, 1955).

The Code listed the types of items that should be included in a maintenance program, but the list was not meant to be inclusive. Rather, the intention was to provide examples of the magnitude and detail that would be considered adequate by the Committee. The objective of the B31.1.8 Committee was that each operator should develop a comprehensive, well-managed program that:

> "…will put the company in compliance with the Code and will provide for a degree of maintenance that will go far toward eliminating any tendency on the part of government officials to try to spell out in detail the amount and extent of maintenance work that a company should do" (Hough, 1955).

It should be noted that the B31.8 Code, and the earlier B31.1.8 Code, did not specify intervals or frequencies for conducting specific maintenance and operating activities. The Code simply stated that periodic inspections or tests were required, and left the interval to be determined by the operator based on system specific conditions and prudent engineering practices. Some equipment, such as rectifiers and related corrosion control activities, are highly dependent on location specific conditions. An experienced operator knows that inspection intervals should be different for each set of circumstances.

7.2 Regulatory Requirements

Specific intervals were introduced when DOT issued the Pipeline Safety Regulations in 1970, replacing "periodic" with a defined interval that could be inspected/audited. The intent of the Code was to have each individual operator use an inspection level that was suitable for the local conditions in which the equipment operated. The intervals were based on general industry practices and available technologies at the time. Discussions among TPSSC members identified the common practices of the late 1960's.

8.0 Public Communications

8.1 Code Considerations

The issue of public education has been an industry concern since pipelines were first put in the ground. In fact, incident reports indicate that external force damage, such as those caused by excavation equipment, is the leading cause of pipeline damage and has been since the causes of pipeline incidents were first compiled in 1966 (Congressional Research Service, 1986).

Public communications and education were not explicitly addressed in the early editions of Code B31.1.8 or B31.8.[8] However, pipeline operators worked to maintain good public relations, particularly in areas where a pipeline was only accessible from an individual's property. Public education activities provided a means for pipeline representatives to meet landowners and gave landowners an opportunity to voice any concerns.

Voluntary industry participation in One-Call programs went a long way toward reducing damage to pipelines from outside sources. These programs were developed to make the general public aware of the pipeline, to encourage people to call prior to digging, and to encourage landowners to call if they saw someone else digging. To promote these activities, pipeline operators would often hold local meetings with contractors, public officials, landowners, farmers, and developers. Calendars and other giveaway items were also used to keep the gas operator's phone number readily accessible to the landowner. These activities are still used in practice today.

8.2 Regulatory Requirements

Requirements for public communication efforts were first included in 49 CFR Part 192.615 (Amendment 192-24 41 FR 13587 March 31, 1976) under the section on emergency plans. The regulations required pipeline operators to establish educational programs to enable customers and the general public to recognize and report a gas emergency. In 1994, these requirements were moved to a new section on public education efforts (49 CFR Part 192.616 Amendment 192-71, 59 FR 6585, February 11, 1994).

[8] A section on educational programs was added to B31.8 (850.44) in 1982 to enable landowners to recognize and report gas emergencies, including activities near a pipeline and any observed damages or leaks.

9.0 Conclusions

Based on the meetings held for this project, it is interesting to note that the concerns of the industry when the 1955 Code Committee was initially developing standards for gas pipelines remain the major concerns of operators today – maintaining the safety of the pipeline system while economically transporting natural gas.

The original B31.1.8 Committee designed the Code with three primary objectives:

1. To represent the established, good engineering practices used to develop, operate, and maintain the existing infrastructure, such that the industry would not be burdened with having to replace vast amounts of good pipe;
2. To make the standards acceptable to the federal government and the public, such that federal regulations (i.e., the Heselton Bill) would not be needed; and
3. To use in material and construction bid documents.

The Code was based on the technological developments of the time, and it was during this time that the industry was rapidly developing new technologies. The Committee wanted the Code to be applicable to current best practices, but flexible enough to provide for new innovations and experience gained by the industry. In fact, during this time, the PRC was formed to develop research efforts in support of the Code. As the research results became available, they were included in the technical discussions supporting the Code development and modifications.

The language used in the 1955 and 1958 versions of the Code was specifically chosen to be performance based. The Committee set out to document safe, acceptable practices and not to prescribe actions. Performance based language carried over into the original Pipeline Safety Regulations. In fact, many of the broad, philosophical considerations of the Code served as the foundation of the Regulations as well.

In the current regulatory environment, it is important to observe that the original intent of the Code was performance and was not to be as prescriptive as the requirements imposed by regulations. To facilitate enforcement, regulations have moved away from being performance based to being more prescriptive. Over time, the Code has been modified to more closely reflect the regulations. For all practical purposes, the U.S. pipeline operators are not compelled to use the Code because the U.S. pipeline industry is regulated by 49 CFR Part 192.

A worldwide initiative is currently underway to develop an international code for pipelines: *ISO/DIS 13623 Pipeline Transportation System for the Petroleum and Natural Gas Industries*. This document is written to satisfy all world conditions related to pipelines. The current B31.8 Committee is also trying to make the Code more applicable to international operations since many of the U.S. gas pipeline companies have or are developing international interests.

Technological developments and engineering advances continue to improve pipeline operations and safety. The pipeline industry works to incorporate these changes into their codes and standards, and the continued development and use of the Code complements the development of the regulatory requirements. Through an understanding of the Code's foundations, the current gas pipeline industry has an opportunity to work with OPS to restore the original performance intentions of the Code and to provide for continued public benefit and improved safety.

10.0 References

American Society of Mechanical Engineers, *Gas Transmission and Distribution Piping Systems ASME Code for Pressure Piping, B31 An American National Standard*, ASME B31.8-1995 Edition, December 7, 1995.

Bergman, Stephen A., "Why Not Higher Operating Pressures for Lines Tested to 90 percent SMYS," *Pipeline and Gas Journal*, December, 1974.

Congressional Research Service, *Pipeline Safety – The Rise of the Federal Role*, U.S. House of Representatives Committee on Energy and Commerce, Washington D.C., March 1986.

Docket OPS-3. *Title 49 - Transportation, Chapter 1 – Hazardous Materials Regulations Board*, Department of Transportation. Part 190 - Interim Minimum Federal Safety Standards for the Transportation of Natural and Other Gas by Pipeline, and Part 192 – Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards. Establishment of Minimum Standards. August 10, 1970.

Duffy, A.R., G.M. McClure, W.A. Maxey, and T.J. Atterbury, *Study of Feasibility of Basing Natural Gas Pipeline Operating Pressure on Hydrostatic Test Pressure*, American Gas Association, Catalogue No. L30050, February 1968.

Eiber, R. J., and W.B. McGehee, *Design Rationale for Valve Spacing, Structure Count, and Corridor Width*, Pipeline Research Committee International, May 1997.

Hough, F.A., "The Gas Industry Has Approved Its New Safety Code," *Gas*, November 1954, pp. 31-33.

Hazardous Materials Regulation Board, "Minimum Federal Safety Standards for Gas Pipeline," *Federal Register*, U.S. Department of Transportation, Vol. 35, No. 57, March 24, 1970.

Hazardous Materials Regulation Board, "Establishment of Minimum Standards," *Federal Register*, U.S. Department of Transportation, Title 49, Chapter 1, Parts 190 and 192, August 18, 1970, pp. 13248-13276.

Hough, F.A., "The New Gas Transmission and Distribution Piping Code, *Gas*, Part 1: The History and Development of the Code," January 1955; Part 2. "Materials and Equipment: Chapter 1 of the Code," February 1955; Part 3. "Chapter 2. Welding on Completed Pipe," March 1955; Part 4. "Chapter 3. Piping and Fabrication," April 1955; Part 5. "Relating Design of Facilities to the Requirements of the Location," May 1955; Part 6. "Corrosivity of Gases and Soils and the Prevention of Over-Pressuring," June 1955; Part 7. "Construction and Testing Methods," July 1955; Part 8. "Code's Outline is Pattern for Top-Managed Maintenance Plan," September 1955.

McGehee, W. B., *Maximum Allowable Operating Pressure (MAOP) Background and History*, Draft Report, Gas Research Institute, Chicago, Illinois, June 1998.

Sparks, Cecil R., et al., *Remote and Automatic Main Line Valve Technology Assessment,* Final Report, GRI-95/0101, Gas Research Institute, Chicago, Illinois, July 1995.

Sparks, Cecil R., et al., *Cost Benefit Study of Remote Controlled Main Line Valves*, Final Report, GRI-98/0076, Gas Research Institute, Chicago, Illinois, May 1998.

ACKNOWLEDGEMENTS

This project was sponsored by the Gas Research Institute (GRI), with leadership and direction by Dr. Keith Leewis. Review and input were provided by the GRI Integrity Maintenance and System Operations Technical Advisory Group (IM&SO TAG), with specific guidance and support provided by Mr. Daron Moore, Mr. Andy Drake, and Mr. John Zurcher.

This report represents a compilation of information and discussions with current and past leaders in the codes and standards area of the natural gas pipeline industry. The authors and the GRI IM&SO TAG members wish to thank the following participants for their time and energy in providing insight into the early development of the B31.8 Code and the Pipeline Safety Regulations (49 CFR Part 192):

Mr. Joseph Caldwell
Mr. Bob Dean
Mr. A.J. (Del) Del Buono
Mr. Bob Eiber
Mr. William Jennings
Mr. John Kiefner
Mr. Angus Macdonald
Mr. Burt Mast
Mr. George McClure
Mr. Wes McGehee
Mr. Al Richardson
Mr. Andy Shoup
Mr. A.W (Red) Stanzel
Mr. A.T. (Red) Tyler
Mr. Tiny Von Rosenberg
Mr. George White

In particular, the efforts of Mr. Wes McGehee and Mr. Al Richardson in organizing the discussion meetings are greatly appreciated.

In addition, the participants respectfully acknowledge the contributions of the 1955 B31.1.8 Committee (listed in Appendix B), and particularly the following individuals who were instrumental in developing the early Code:

Frank Williams: Mr. Williams served as executive chairman of B31.1 and later became chairman of the ASME Boiler and Pressure Vessel Code. Mr. Williams is remembered for his vision and leadership in developing the first comprehensive pipeline Code.

Fred Hough: Mr. Hough was the first Chairman of the B31.8 Code for Pressure Piping Committee. Formerly, he was Vice President of Southern Counties Gas Company and later a consulting engineer with Bechtel Corporation. Because of his leadership and persistence, Mr. Hough is credited for the Code being what it is today.

APPENDIX A

MEETING PARTICIPANTS

The following emeritus participated in the meetings:

Bob Dean: Mr. Dean spent 42 years with Tenneco, where his work experience included drafting, field construction, and supervision. At Tenneco, Mr. Dean moved into Codes and Standards, where he became a B31.8 member and a member of the Gas Piping Technology Committee (GPTC). For 15 years, he served as Vice Chairman of the American Petroleum Institute (API) Committee on Standardization of Tubular Goods and Chairman of the Users Subcommittee on Line Pipe. He has been consulting in the gas industry since 1988.

A.J. (Del) Del Buono: Mr. Del Buono began his career in the gas pipeline business in 1946 with Michigan Consolidated Gas Company, where he worked in specifying, designing, and testing piping components. He also spent three years with Bechtel Corporation in Europe building the Trans-Alpine Pipeline. After attending one of the earliest B31.8 meetings in 1951, Mr. Del Buono went to work for Frank Williams to assist him in research efforts for the B31.8 Committee. He remained active on the Code Committees and was a member of both GPTC and B31.8. He retired from ITT in 1986 to work as a consultant.

Robert Eiber: Mr. Eiber retired from Battelle in 1994 and established a consulting business. Recent studies with Wes McGehee document some of the background for the current MAOP requirements in the U.S. compared to requirements in other countries, the criteria for block valve spacing, and a comparison of class location codes. While at Battelle, Mr. Eiber, along with John Kiefner and George McClure, was involved in the research that defined the basis for Code changes.

John Kiefner: Dr. Kiefner currently operates an engineering company, Kiefner and Associates, Inc., which he established in 1990 after leaving Battelle. Kiefner and Associates, Inc. conducts pipeline research efforts for research organizations, such as GRI and the Pipeline Research Committee, as well as for pipeline operators. His background in pipeline research with Battelle is in the area of remaining strength of corroded pipe.

Angus Macdonald: Mr. Macdonald has been working as a consultant since 1970. Previously he worked for Kaiser Steel Corporation as a metallurgist, with expertise in the area of integrity analysis. He is an active member of the B31.8 Committee and the API Committee on Standardization of Tubular Goods.

Burt Mast: Mr. Mast worked for United Gas Pipeline from 1936 to 1942. After serving in the Air Force during World War II, he went to work for Tennessee Gas in 1946. At that time, Tennessee had a single 24-inch line and they were just starting to build a second line. During most of the 13 years he was with Tennessee, he was the Supervising Engineer. In 1954, he went to work for Trunkline Gas, where he served as a Chief Engineer and Vice President for 13 years. Mr. Mast was a member of the B31.8 Committee and chaired the Design Stresses Subcommittee of the 1955 Committee. He was also one of the charter members of the Technical Pipeline Safety Standards Committee (TPSSC) and served as chairman for ten years. After retiring from corporate life in 1967, Mr. Mast became a consultant.

George McClure: Mr. McClure spent 38 years of his career at Battelle. He was introduced to pipeline research within a few months of joining Battelle in 1949. He became involved in the early American Gas Association (A.G.A.) Pipeline Research Committee work at Battelle and supervised the work until the late 60's or early 70's when he became an Assistant Director of

Battelle's Columbus Laboratory. He was a member of B31.8 and attended all of the meetings until the early 1970's to provide input on the pipeline research efforts. Mr. McClure retired from Battelle in 1987.

Wes McGehee: Mr. McGehee worked for Texas Eastern for 25 years, where his industry background includes Plans and Research, Technical Services, Engineering, and Operations. Since 1986, he has operated a consulting service, where he works primarily with gas and oil pipeline companies. His expertise is in the areas of hydrostatic testing, pipeline maintenance, operation, design, and construction. Mr. McGehee presently serves as the Chairman of the ASME B31.8 Committee.

Al Richardson: Mr. Richardson worked for Tennessee Gas Pipeline for more than 37 years. He is currently president of Richardson Engineering out of Marble Falls, Texas. He has been involved with B31.8 for a number of years and worked for Bob Dean when he was deeply involved in B31.8. Mr. Richardson was witness to the transition from the engineers that built the original pipeline system to the current engineers that operate it today, and has observed the cultural differences between the two groups.

Andy Shoup: Mr. Shoup trained in Civil Engineering and spent most of his career working in the pipeline industry. He initially worked for United Gas, where his first job, in 1939, was building several natural gas pipelines near Monroe, Louisiana. He later spent 25 years at Texas Eastern serving as Vice President and Chief Engineer, Senior Vice President, President, and Chief Executive Officer of Transwestern (a subsidiary of Texas Eastern at that time). He was a charter member of TPSSC and worked on a number of other committees, including B31.8, the Pipeline Research Committee, and other operating committees. He retired in 1971 to become a consultant. In 1974, he was appointed to a court position as Director and Chairman of the Board of LoVaca, which he served until 1982.

Mr. Shoup was a charter member of the B31.8 Code Committee and served as Chairman of the Committee for 18 years. He was also a member of the Design Committee and Pipeline Committee. He retired from the Code Committee in 1990.

A.W. (Red) Stanzel: Mr. Stanzel spent his career with American Natural Resources Pipeline Company. He was involved in the A.G.A. NG-18 Committee for a number of years, and served as Chairman for the last ten years of his career. His areas of expertise include hydrostatic testing and field failure investigation.

A.T. (Red) Tyler: Mr. Tyler began his career in 1941 as a construction engineer for Mene Grande Oil Company. Over the years he has worked for numerous other pipeline companies and engineering companies serving the pipeline industry. He chaired the Design, Installation, Testing and Welding Task Group of the B31.8 Committee, and currently serves in the Executive Committee. Mr. Tyler is also a member of the WG-3 Design Committee for the International Standards Organization (ISO) TC 67 Petroleum and Natural Gas Industries - Pipeline Transportation Systems. He also represents the U.S. on the ISO Committee to develop an international standard for pipelines. He is currently President and CEO of International Pipeline Engineers, Inc.

Tiny Von Rosenberg: Mr. Von Rosenberg has worked in the pipeline industry for 32 years. Over 20 years of this time was spent at Exxon in their research laboratory, where he was instrumental in developing and validating an early analytical model of fracture arrest of propagating ductile fractures. He has wide experience with the design and construction of onshore, offshore, and arctic pipelines. He was involved in the design and construction of the Alyeska Pipeline. After retiring from Exxon in 1986, he organized a consulting firm and has continued his work in both pipeline materials and welding applications.

George White: Mr. White worked for Tennessee Gas Pipeline Company for 38 years, most of the time as Chief Engineer and Vice President. At the time OPS adopted 49 CFR Part 192, he was Secretary of the B31.8 Committee and also served on the API 5L Users Line Pipe Committee. Mr. White was also a charter member of the original TPSSC, serving for three years. Mr. White and Mr. Mast were instrumental in convincing OPS that the original B31.8 Code was the only standard at the time that could serve the industry.

The following former OPS staff also participated in this effort:

William Jennings: Mr. Jennings headed the Law Department of Western Airlines prior to his appointment in 1962 as Executive Director of the Regulatory Council of the Federal Aviation Agency (FAA). In 1966, he was appointed Chairman of the Department of Transportation's Hazardous Materials Regulations Board and also served as Director of the Office of Hazardous Materials. In 1968, Mr. Jennings was named acting Director of the OPS and entrusted with developing the first Pipeline Safety Regulations. He left government service in 1970 to pursue other interests.

Joseph Caldwell: Mr. Caldwell began his career as a safety engineer for an insurance company, where he developed a petroleum oriented safety program for their clients. He then went to work for the FAA as the Regional Safety Engineer. In 1964, he became the Director of Ground Safety for the FAA in Washington D.C. and was there when the Department of Transportation (DOT) was formed in 1966. His 17 years at DOT began with the drafting of the Pipeline Safety Act in 1968 and continued through development and implementation of the basic pipeline safety regulations for both gas and hazardous liquid pipelines. Mr. Caldwell served as the Deputy Director and later Director of the OPS. For the past 14 years, Mr. Caldwell has been a consultant to the pipeline industry and related industries, state and federal agencies, and the public on matters relating to pipeline safety and safety regulations.

Other attendees at the meetings included:

Keith Leewis (moderator and GRI Project Manager): Dr. Leewis currently works for the Gas Research Institute, where he has been instrumental in developing the risk management applications for pipelines. His background is in metallurgy and welding. Prior to GRI, he worked on the TransCanada Pipeline system, with experience in failure analysis, automatic welding, x-ray, and non-destructive testing. He has also been involved with the Pipeline Research Committee *I*nternational (PRC*I*), first as a contractor and then as a pipeliner.

Jim Kelly: Mr. Kelly works in the Codes group for Duke Energy and currently serves on the B31.8 Committee.

Daron Moore: Mr. Moore is responsible for Codes and Standards and pipeline safety operational risk management at Tennessee Gas Pipeline. He is active on the B31.8 Committee and GPTC.

Andy Drake: Mr. Drake is Manager of Codes and Standards at Duke Energy.

APPENDIX B

1955 B31.1.8 COMMITTEE MEMBERS

1955 B31.1.8 Committee Members

<table>
<tr><td colspan="3">Officers (to January 1955):
F. A. Hough, Chairman
W.H. Davidson, Vice-Chairman
C.F. de Mey, Vice-Chairman
C.T. Schweitzer, Secretary</td><td colspan="3">Officers (after January 1955):
J.H. Carson, Chairman
W.H. Davidson, Vice-Chairman
C.F. de Mey, Vice-Chairman
J.F. Eichelmann, Vice-Chairman
B.C. White, Vice-Chairman</td></tr>
<tr><td colspan="3">Subgroup Chairmen (to January 1955):
M.C. Madsen, Compressor Stations
M.H. Davidson, Construction, Testing, and Operating
B.T. Mast, Design Stresses
F.G. Sandstrom, Distribution
F.S.G. Williams, Fabricating Details and Mechanical Design
C.F. de Mey, Pipe
J.F. Eichelmann, Scope
S.A. Bergman, Investigation of Transmission and Distribution
R.D. Smith, Storage in Pipe</td><td colspan="3">Subgroup Chairmen (after January 1955):
B.T. Mast, Compressor Stations
F.G. Sandstrom, Distribution
S.A. Bergman, Facility Failures
W.M. Frame, Materials
F.S.G. Williams, Mechanical Design and Fabrication
H.L. Stowers, Research
F.A. Hough, Scope
R.D. Smith, Storage in Pipe
J.J. King, Transmission</td></tr>
<tr><td colspan="6">Members:</td></tr>
<tr><td colspan="2">Clyde D. Alstadt
Columbia Gas System Service Corporation</td><td colspan="2">John H. Carson
The East Ohio Gas Company</td><td colspan="2">G.G. Dye
Southern California Gas Company</td></tr>
<tr><td colspan="2">H. Bruce Andersen
Philadelphia Gas Works Company</td><td colspan="2">R.A. Cattell
Petroleum & Natural Gas Branch
U.S. Bureau of Mines</td><td colspan="2">W.M. Frame
National Tube Division
United States Steel Corporation</td></tr>
<tr><td colspan="2">Richard Aubrey
Kaiser Steel Corporation</td><td colspan="2">O.W. Clark
Southern Natural Gas Company</td><td colspan="2">John F. Eichelmann
El Paso Natural Gas Company</td></tr>
<tr><td colspan="2">Stephen A. Bergman
Panhandle Eastern Pipe Line Company</td><td colspan="2">Anthony H. Cramer
Michigan Consolidated Gas Company</td><td colspan="2">Julian L. Foster
Lone Star Gas Company</td></tr>
<tr><td colspan="2">Victor F. Bittner
Peoples Gas, Light & Coke Company</td><td colspan="2">F.G. Crawford
The Fluor Corporation, Ltd.</td><td colspan="2">George E. Fratcher
A.O. Smith Corporation</td></tr>
<tr><td colspan="2">Norman F. Blundell
Gulf Interstate Gas Company</td><td colspan="2">Kirby E. Crenshaw
Gas Advisers, Inc.</td><td colspan="2">John L. Gere
Cities Service Gas Company</td></tr>
<tr><td colspan="2">Mathew M. Braidech
National Board of Fire Underwriters</td><td colspan="2">Walter H. Davidson
Transcontinental Gas Pipe Line Corporation</td><td colspan="2">James W. Hall
Hallmac Construction Company</td></tr>
<tr><td colspan="2">J.A. Bramblett
Fall River Gas Works Company</td><td colspan="2">Charles F. de Mey
Columbia Gas System Service Corporation</td><td colspan="2">M.M. Heller
United Gas Pipe Line Company</td></tr>
<tr><td colspan="2">Fred H. Bunnell
Consumers Power Company</td><td colspan="2">C.A. Dunlop
Humble Oil and Refining Company</td><td colspan="2">E.L. Henderson
United Gas Corporation</td></tr>
</table>

1955 B31.1.8 Committee Members, continued

E.N. Henderson Arkansas Louisiana Gas Company	M.C. Madsen Northern Natural Gas Company	J.C. Siegle Youngstown Sheet & Tube Company
Robert F. Henderson Ford, Bacon and Davis, Inc.	B.T. Mast Trunkline Gas Company	D.P. Smith Michigan – Wisconsin Pipe Line Company
C.A. Henrikson United States Pipe & Foundry Company	George W. McKinley Hope Natural Gas Company	Roscoe D. Smith Pacific Gas and Electric Company
Hugh H. Hunter Public Service Commission of Maryland	P.A. Mills Moody Engineering Company	B.W. Snyder Canadian Western Natural Gas Company Ltd.
Frederic A. Hough Bechtel Corporation, Pipeline Division	George D. Mock Washington Gas Light Company	Professor M.G. Spangler Iowa State College
Hugh H. Hyde Bechtel Corporation	J.J. Murphy M.W. Kellogg Company	F.E. Stanley Midwestern Constructors, Inc.
Lloyd R. Jackson Battelle Memorial Institute	Henry W. Nicolson Public Service Electric and Gas Company	H.L. Stowers Texas Gas Transmission Corporation
Carl T. Kallina Federal Power Commission	Paul E. Noll United States Steel Corporation	Professor Harry Udin Massachusetts. Institute of Technology
L.W. Kattelle Walworth Company	Preston Parks Colorado Interstate Gas Company	J. Thompson Vann American Cast Iron Pipe Company
J.J. King Tennessee Gas Transmission Company	M.J. Paul Natural Gas Pipeline Company of America	P.K. Wallace Oklahoma Natural Gas Company
W.P. Kliment Crane Company	J.R. Reeves Dominion Natural Gas Company, Ltd.	B.C. White Stone & Webster Engineering Corporation
Carl F. Koenig, III DeLaval Steam Turbine Company	F.G. Sandstrom Consolidated Edison Co. of N.Y., Inc.	Frank S.G. Williams Taylor Forge & Pipe Works
H.W. Ladd Stanolind Oil & Gas Company	W.H. Savage Robert W. Hunt Company	Carl K. Wirth State of Michigan Public Service Commission
Henry C. Lehn	C.T. Schweitzer Southern California Gas Company	Dean M. Workman Ebasco Services, Inc.
Giles R. Locke Republic Steel Corporation	A.J. Shoup Texas Eastern Transmission Corporation	Professor E.C. Wright University of Alabama